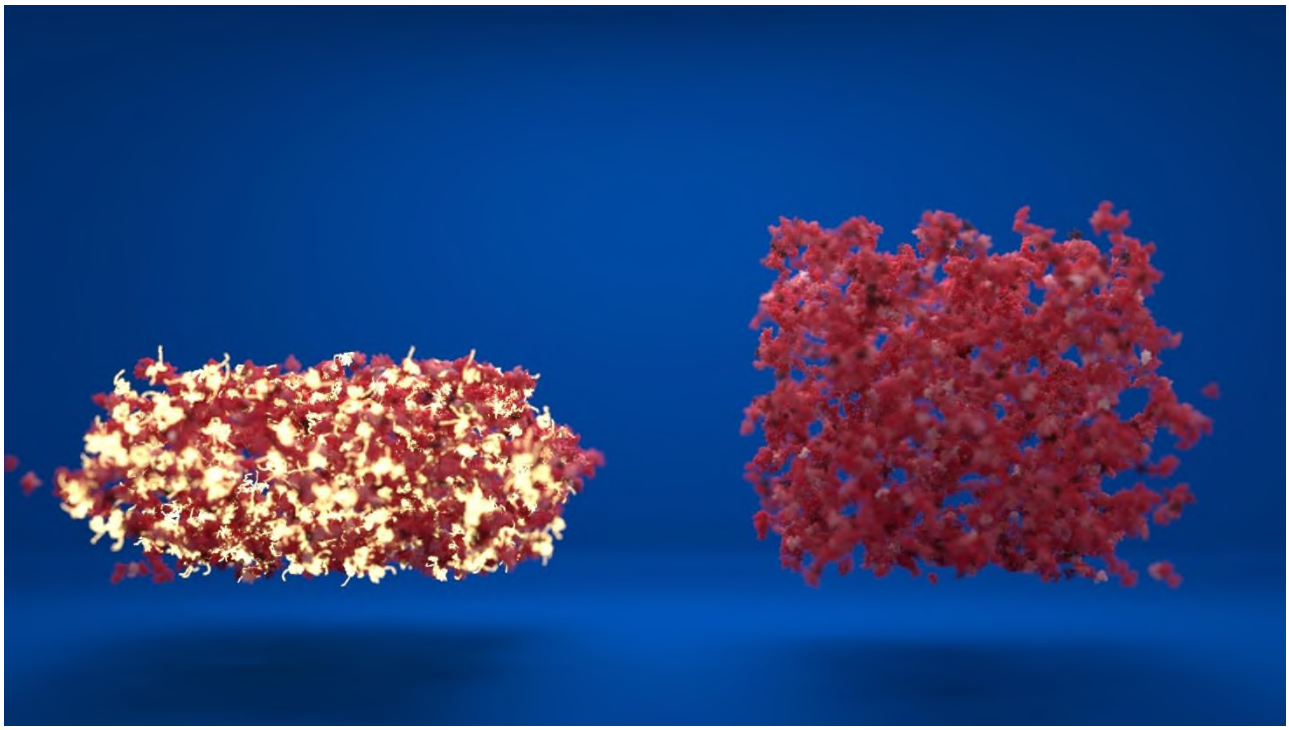
Name(s) of Supervisor(s): Lorna Dougan, Sarah Harris and Daniel Read

University (or universities) and Department(s): School of Physics and Astronomy, University of Leeds

Studentship Project Title/Theme: Designer meso-materials: developing new tools to understand and create responsive and functional protein-based biomaterials

Protein hydrogels can form when folded proteins are linked together to form an intricate network. But these folded proteins don't always neatly keep their shape when they are linked together. Sometimes they bind neighbouring proteins that are moving in opposite directions. This causes the protein to be pulled apart when the gel is forming, leading to flexible areas between more rigid clusters of folded protein. Using nano-staples to manipulate how readily protein unfolds means that we can design flexible hydrogels with more unfolded protein, or rigid hydrogels with tightly folded protein. Each has different architecture and mechanical properties while keeping the protein's biological functionality intact. This makes custom built protein hydrogels useful for a wide range of applications.



This **new** project will exploit integrative experimental and modelling tools to understand and exploit force-induced unfolding of proteins at the nanoscale and the resultant impact on impact on protein network formation. The project will be based in the multidisciplinary Dougan, Harris and Read groups, and will benefit from strong links to the Astbury Centre for Structural and Molecular Biology and the Bragg Centre for Materials Research. The student will have access to and training in a wide range of soft matter techniques spanning multiple length scales, offering powerful opportunities to widen our characterization and control of hydrogels. Experimental techniques will include rheology, scattering, circular dichroism, dynamic light scattering, and differential scanning calorimetry, making use of state-of-the-art facilities at Leeds and both the Diamond Light Source and ISIS neutron and muon facility,

Oxford. Modelling will employ Fluctuating Finite Element Analysis (FFEA), a pioneering method developed at Leeds. FFEA is an open source software tool for mesoscale biomolecular simulations that aims to bridge this gap in time and length-scales. FFEA uses continuum mechanics to model proteins at the ultra coarse-grained level. Training in computational modelling will be provided commensurate with the student's interests and experience, potentially including the utilisation and/or development of FFEA coarse-grained methodologies, improvement of our numerical algorithms and their usability and use of Leeds' high-performance computing (HPC) facilities. The student will have opportunities to develop public engagement (PE) activities as part of a wider group effort to Create Materials Innovation (www.CreateMaterialsInnovation.com).

Useful references include:
Soft Matter, 16, 6389 (2020), Macromolecules, 53, 7335 (2020), Biomacromolecules, 14, 4253 (2020), ACS Nano, 15, 11296 (2021) and PLoS Comput Biol 14(3): e1005897.